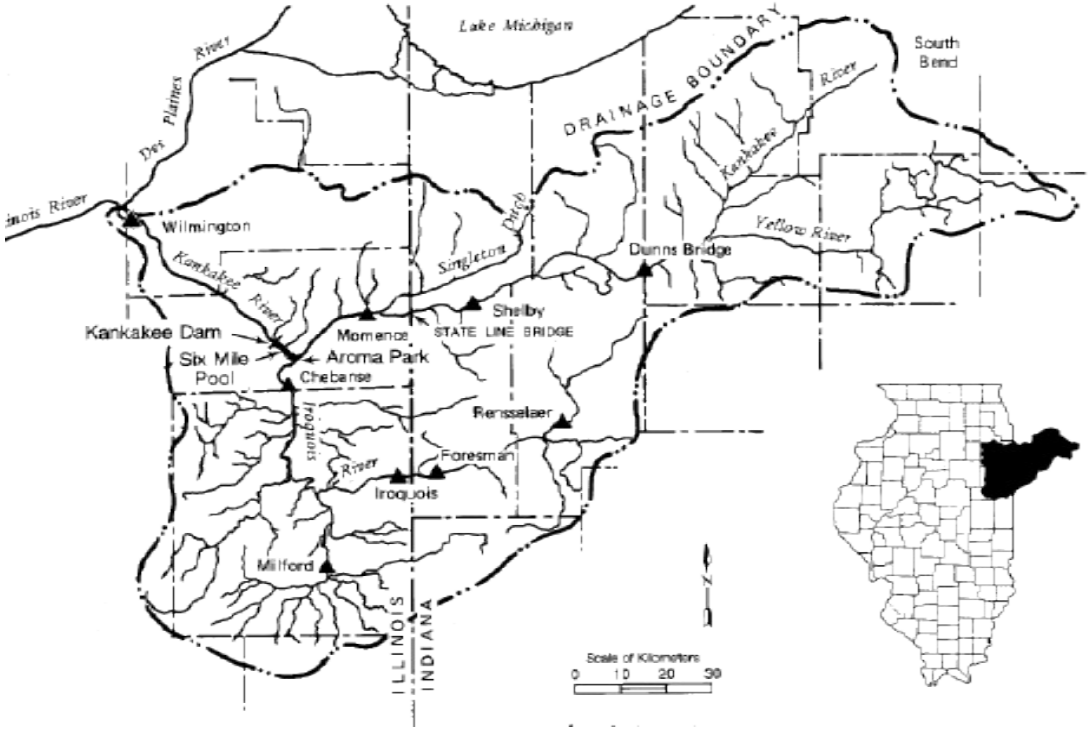
Application of Sediment Impact Analysis Method (SIAM) in the Kankakee River Basin, Indiana and Illinois



Meg Jonas and Charles Little, ERDC Coastal & Hydraulics Laboratory
Brad Thompson: Rock Island District

May 2008

Where?

- South Bend, Indiana to its confluence with the Des Plaines => Illinois River
- 5,165 square mile drainage area
  - 2,169 square miles in Illinois
  - 2,996 square miles in Indiana.
- Length of ~ 150 miles mainstem
  - Indiana portion channelized by 1918, Illinois mainstem left natural
  - Historic Indiana portion was Grand Kankakee Marsh, 400,000-acre freshwater marsh (625 sq miles) – 3 to 5 miles wide, 1 to 4 feet water depth

Problem Definition

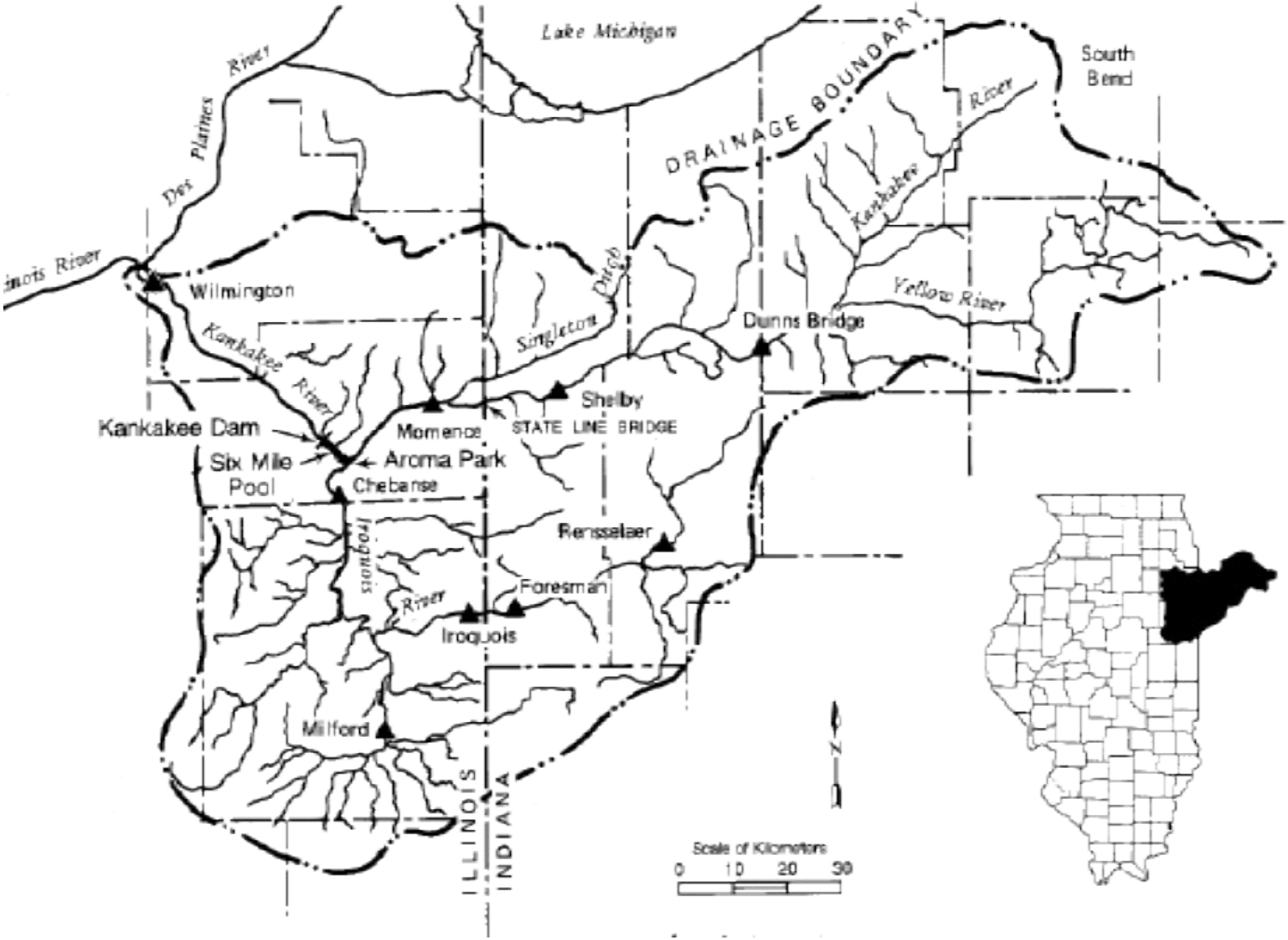
- Historic concerns over sedimentation
- Illinois:
  - Wetlands downstream of state line
  - Areas of gravel / cobble substrate
  - Side Channels
- Indiana:
  - Downstream portion of Yellow River (elevation of channel bed is above adjacent wetlands; water diversions into wetland are by gravity)

Illinois River Basin Collaboration Opportunities

- Illinois River Basin Restoration Comprehensive Plan – partnership opportunity
- Addressing sediment as a misplaced resource is a major focus of the proposed multi-billion interagency restoration program for the Illinois River Basin
- Partnerships on Kankakee
  - Two divisions (MVR & LRD)
  - Three districts
  - Two states (IL & IN)

Benefits and Advantages

- Partnership using study and RSM funds on the Kankakee River Basin is very helpful. Sedimentation issues along the river have historically been a problem for both states and divisive at times.
- Currently both states are very excited about assistance in better defining the problems and identifying potential solutions so positive actions can take place.
- Potential is good for additional joint efforts with RSM in the future, for instance, a study of the Yellow River (major sediment producing tributary to the Kankakee River). Support of additional RSM funds is likely to be a major incentive for sponsors given the scope of the problems, and the multi-state issues.

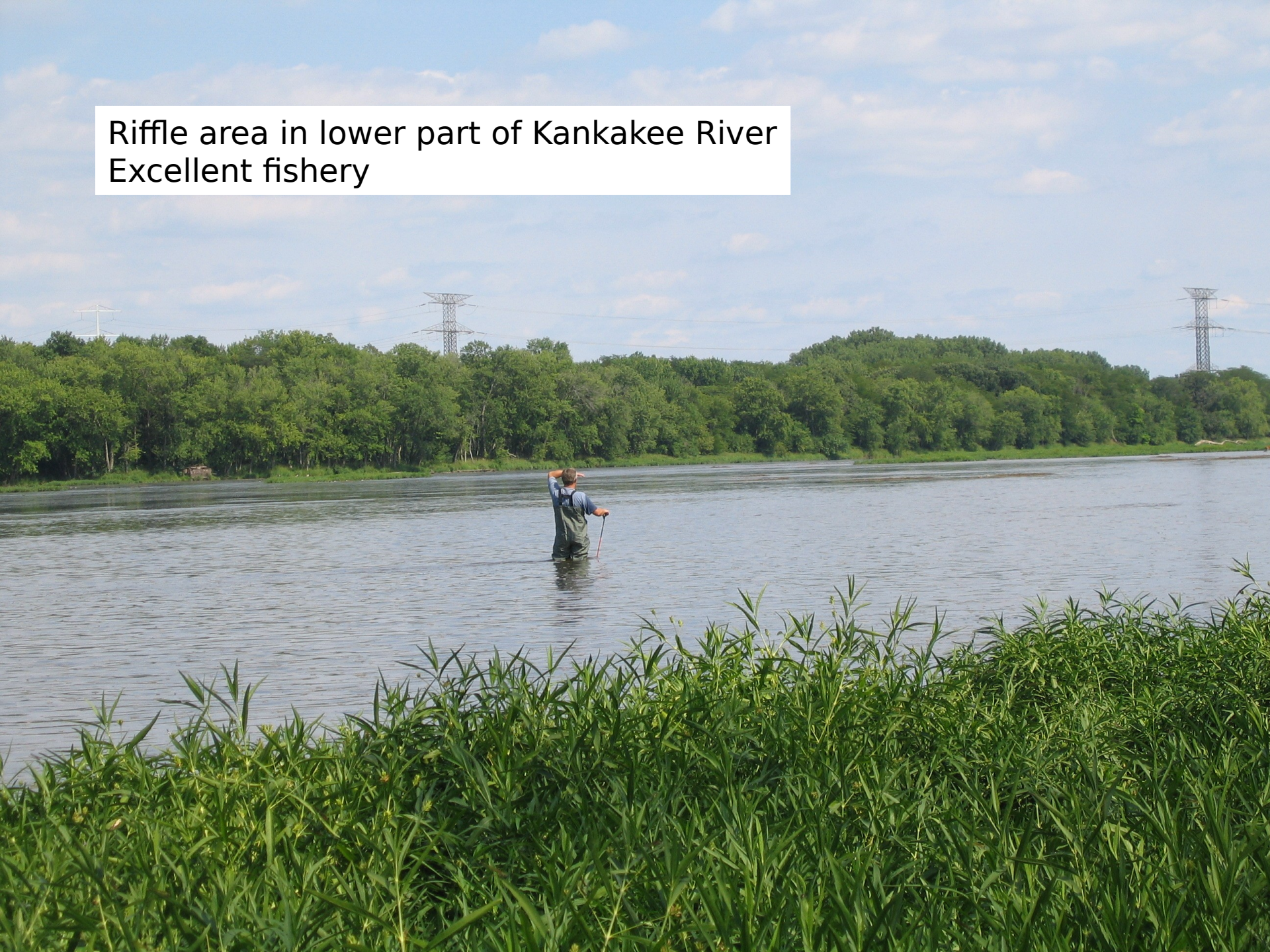


Kankakee River Basin, Illinois and Indiana

First, a quick tour of the watershed…

- Watershed land use primarily agriculture

Agricultural ditches for drainage


Riffle area in lower part of Kankakee River
Excellent fishery

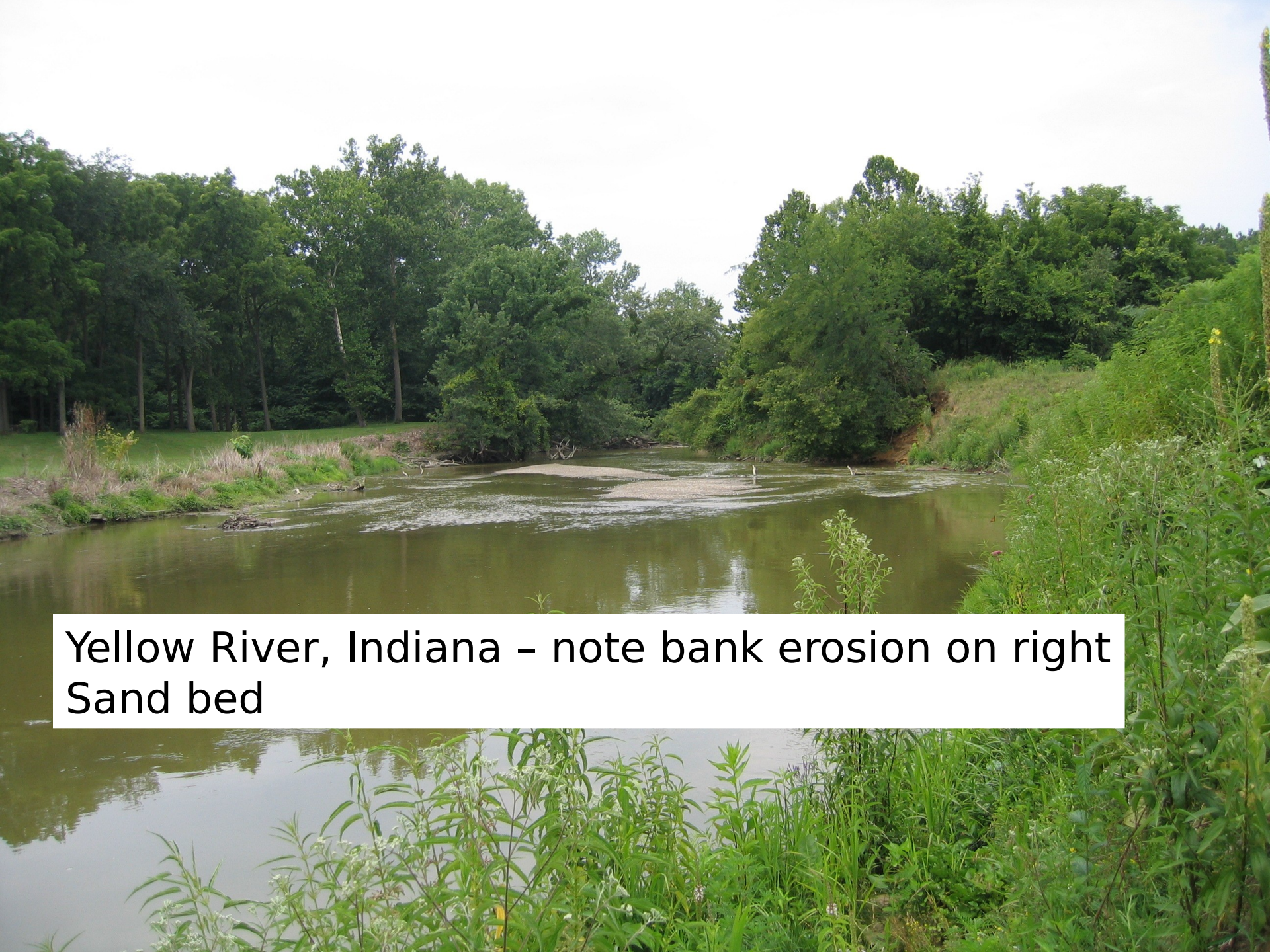
Coarse substrate is typical of the lower Kankakee River

Sedimentation is a concern in the lower Kankakee River

Kankakee River near Indiana state line
Sand bed channel

Yellow River, Indiana
Aggradation near mouth. Sand bed.
Channel bed here is perched above adjacent fields and wetland ar

Gravity drainage from perched river channel of Yellow River (far right) into wetland on left. Pumps have been removed.

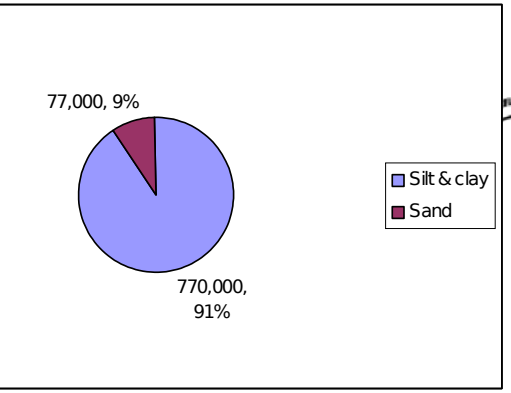


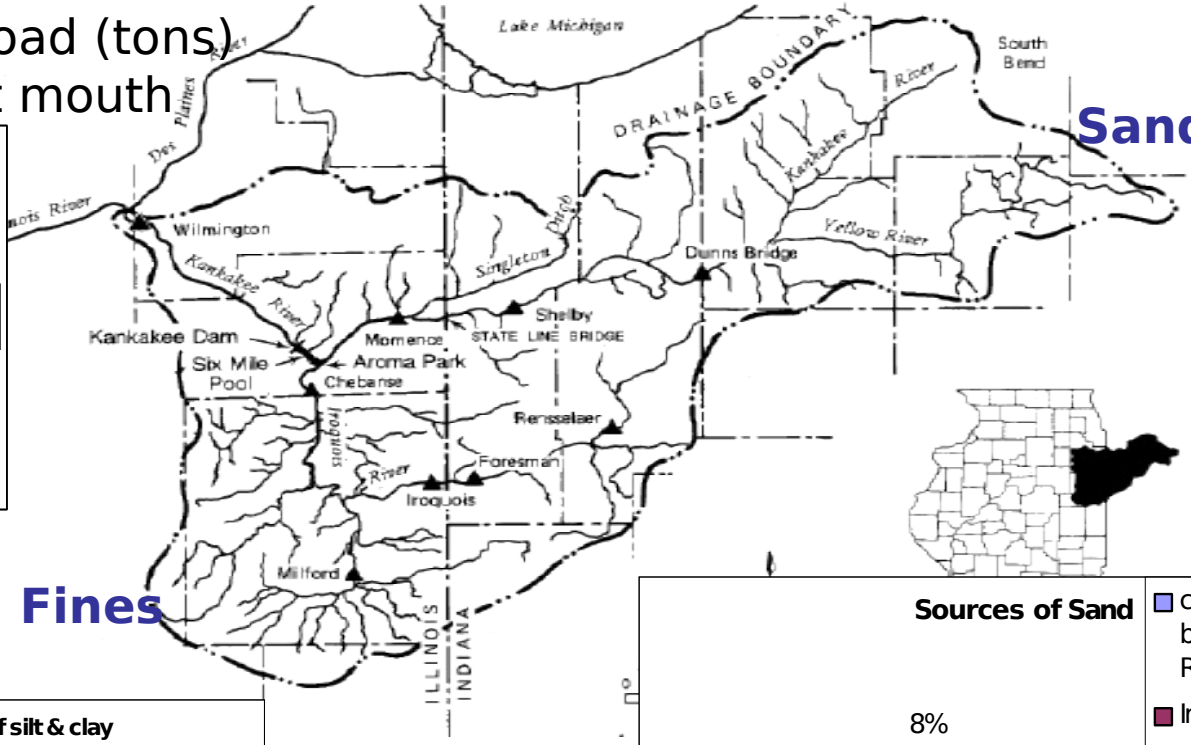
Yellow River, Indiana – note bank erosion on right
Sand bed

Yellow River, Indiana
Sand contribution from eroding ba
100% sand
100% delivery ratio

Kankakee River Basin, Illinois and Indiana
Sources of Fine and Coarse Sediment
(estimates derived from multiple reports)

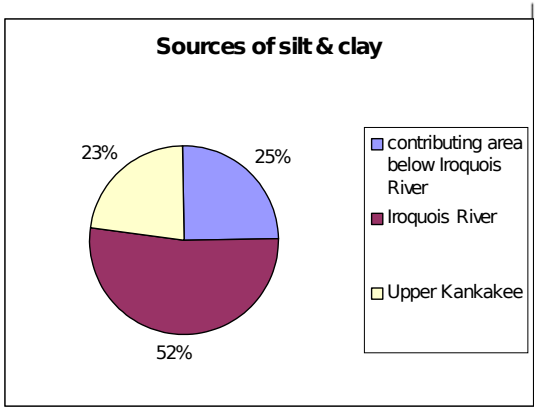
Average Annual Load (tons)
Kankakee River at mouth

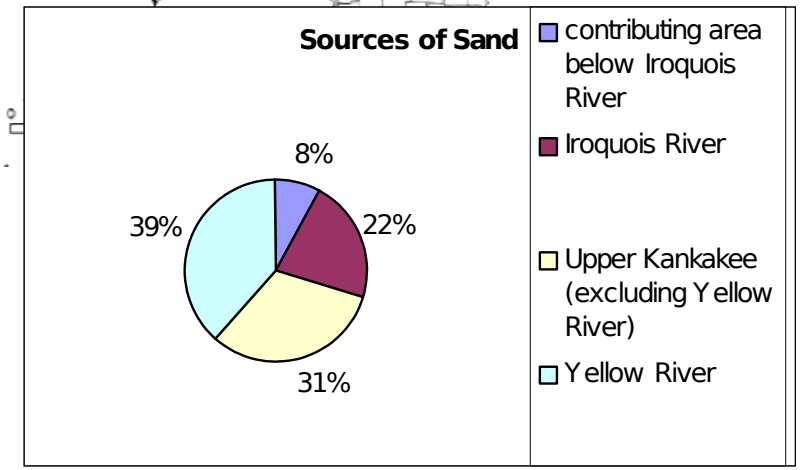


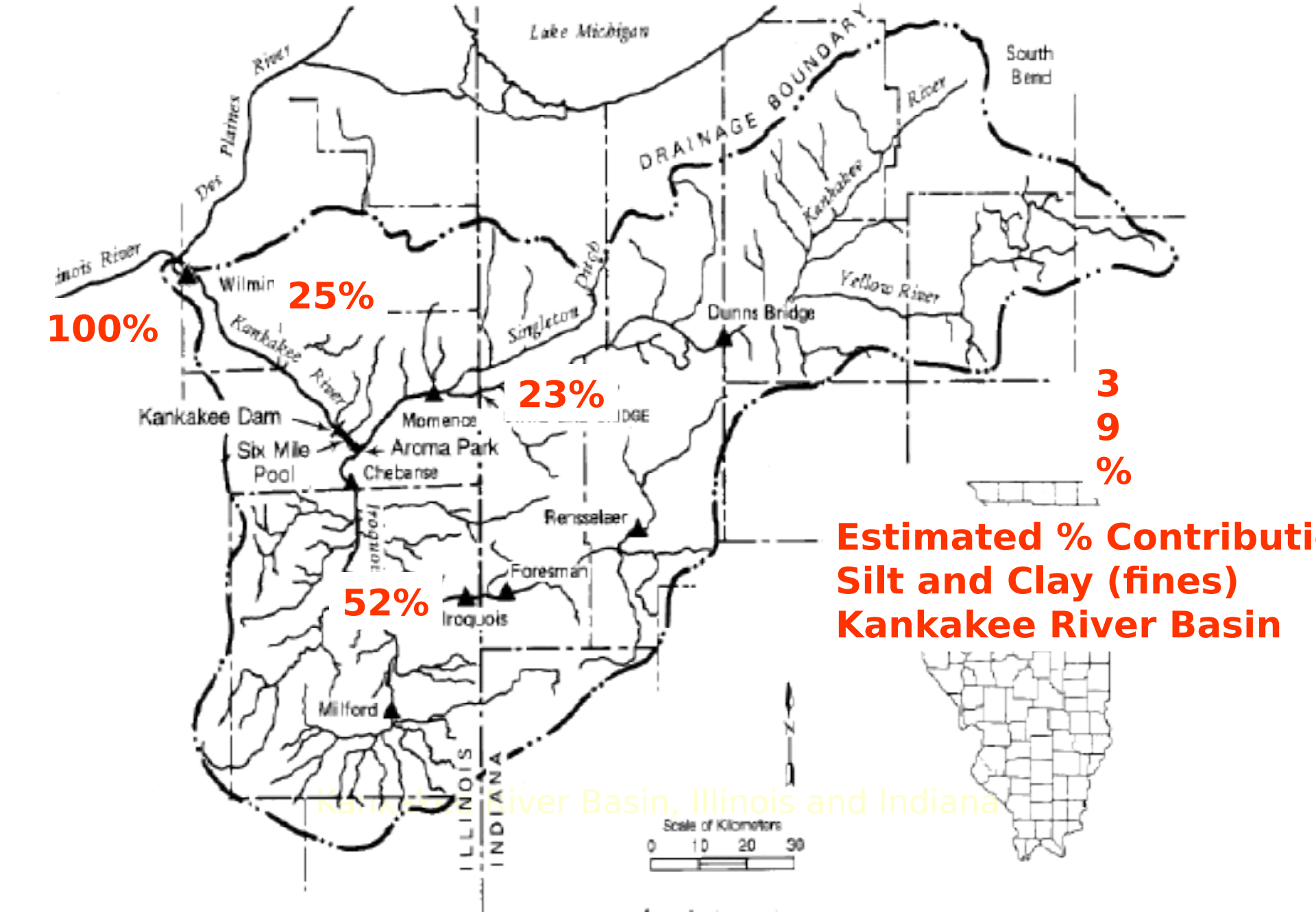


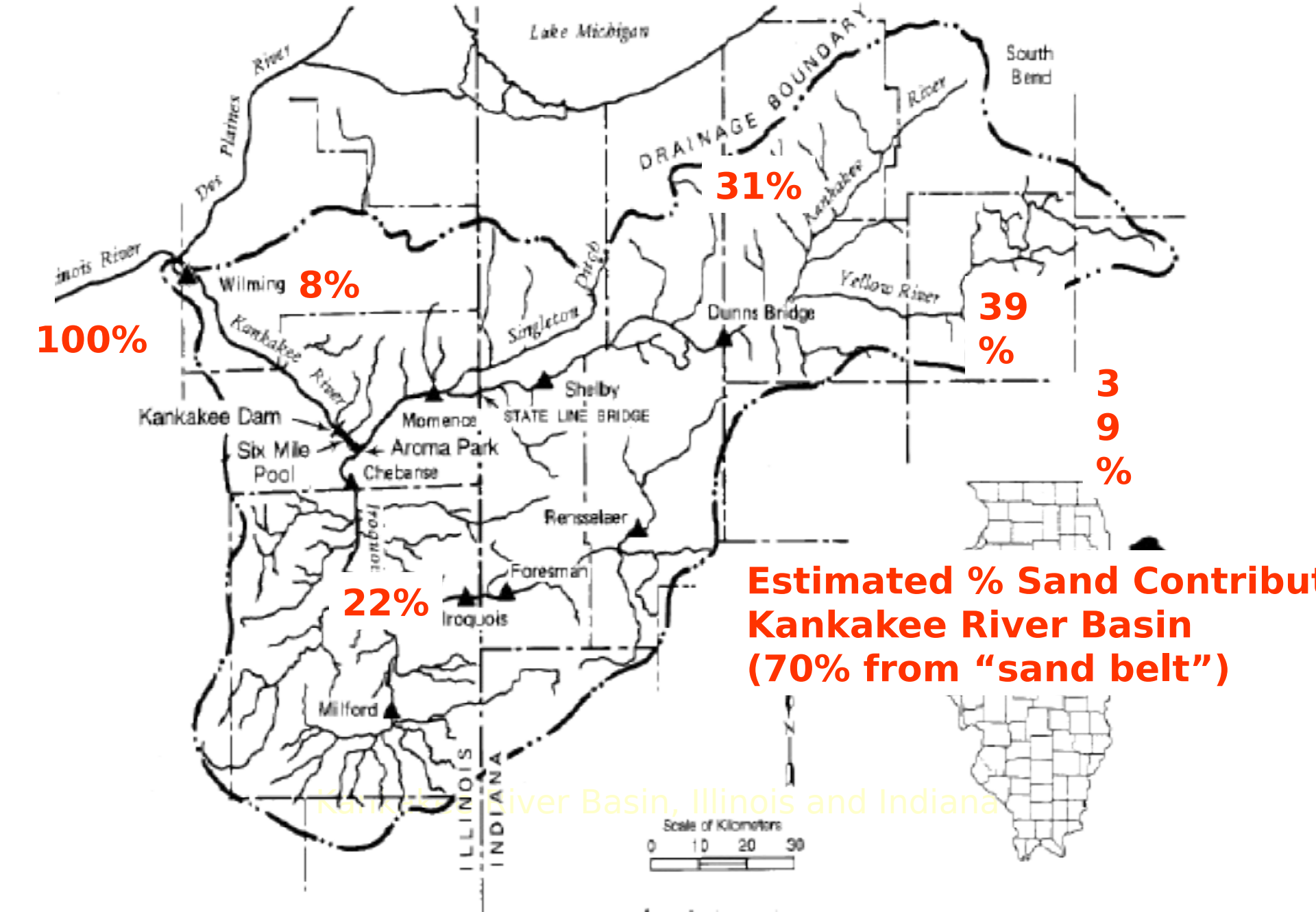
Sand belt

Fines

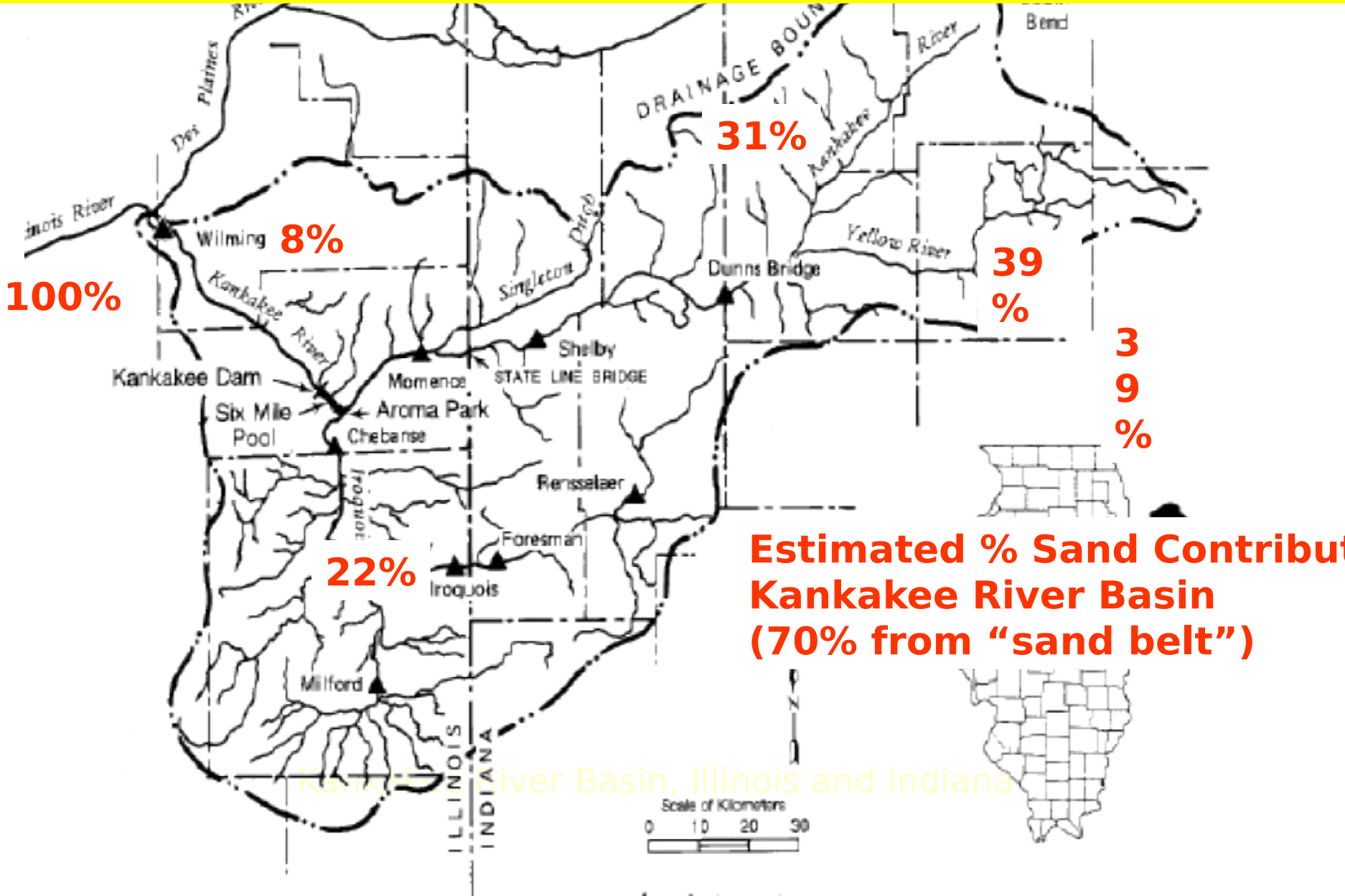





Lake Michigan
DRAINAGE BOUNDARY
South Bend
Des Plaines River
Kankakee River
Yellow River
Singleton Ditch
Wilmington
Dunns Bridge
Kankakee Dam
Six Mile Pool
Momence
Aroma Park
Chebanse
Iroquois River
Rensselaer
Foresman
Iroquois
Milford
ILLINOIS
INDIANA
100%
25%
23%
52%
3
9
%
Estimated % Contributi
Silt and Clay (fines)
Kankakee River Basin
Kankakee River Basin, Illinois and Indiana
Scale of Kilometers
0 10 20 30
N


Lake Michigan
DRAINAGE BOUNDARY
South Bend
Des Plaines River
Illinois River
Wilming
8%
100%
Kankakee River
Singleton Ditch
Yellow River
31%
39 %
3 9 %
Dunns Bridge
Shelby
STATE LINE BRIDGE
Momence
Kankakee Dam
Six Mile Pool
Aroma Park
Chebanse
Iroquois River
Rensselaer
Foresman
22%
Iroquois
Milford
ILLINOIS
INDIANA
Kankakee River Basin, Illinois and Indiana
Scale of Kilometers
0 10 20 30
N
Estimated % Sand Contribut
Kankakee River Basin
(70% from “sand belt”)

If a project goal is to decrease the amount of sand that gets to Kankakee, what alternatives should be considered?



Sediment Transport Mechanisms

- Wash load: not found in significant quantities in the bed; delivery dependent on supply. Clay and silt are typically wash load, sand sizes and larger may be wash load as well.
- Bed material load: found in significant quantities in the bed of the channel; delivery dependent on transport capacity.

Material that is wash load upstream may be bed material downstream.
A decrease in wash load in a reach upstream may have no impacts locally, but may cause impacts to the bed in a reach downstream.

DEFINITIONS OF TOTAL SEDIMENT LOAD

9COPE116

If incoming supply of bed material is decreased, the flow will pick up additional material from the bed to compensate. No decrease will be seen downstream.

Yellow River, Indiana: sand bed, and sand bank contribution
If bank erosion on right is stabilized, what will happen to the sediment load?
Here?
Further downstream?

Wash Load Threshold May Vary from Reach to Reach

Sand bed in Yellow River and Upper Kankakee

Cobble bed in lower Kankakee (downstream coarsening unusu

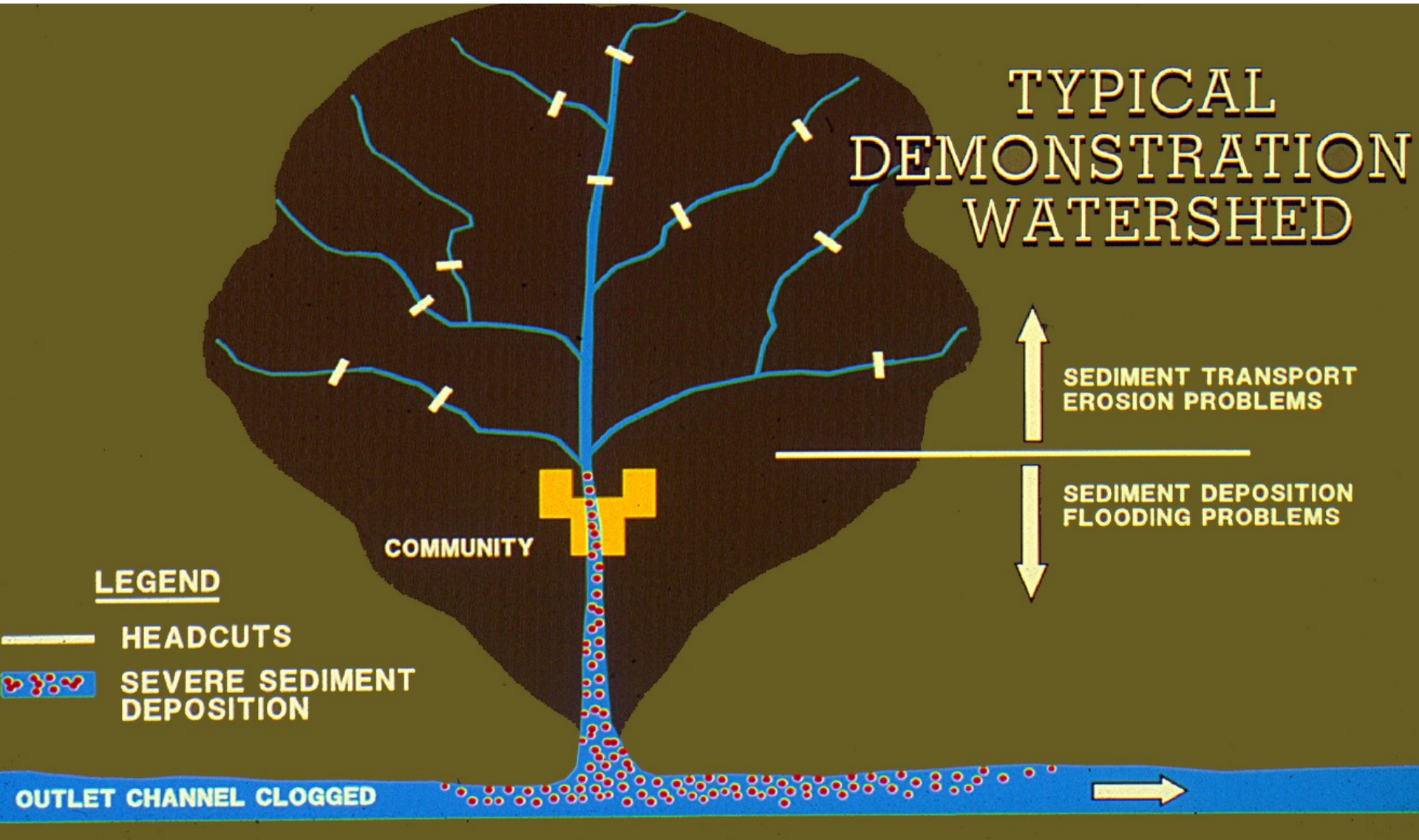
A Systems Approach to Watersheds

- Watersheds are networks of alluvial channels
- Actions taken at one site may have impacts onsite, upstream, or downstream
- Actions that affect sediment loads or transport capacity may have impacts on the stability of reaches: onsite, upstream or downstream
- Sediment has a dual role as pollutant and as the “building block” that forms the channel and floodplain

Needed: analysis tool for quickly evaluating impacts of sediment management alternatives

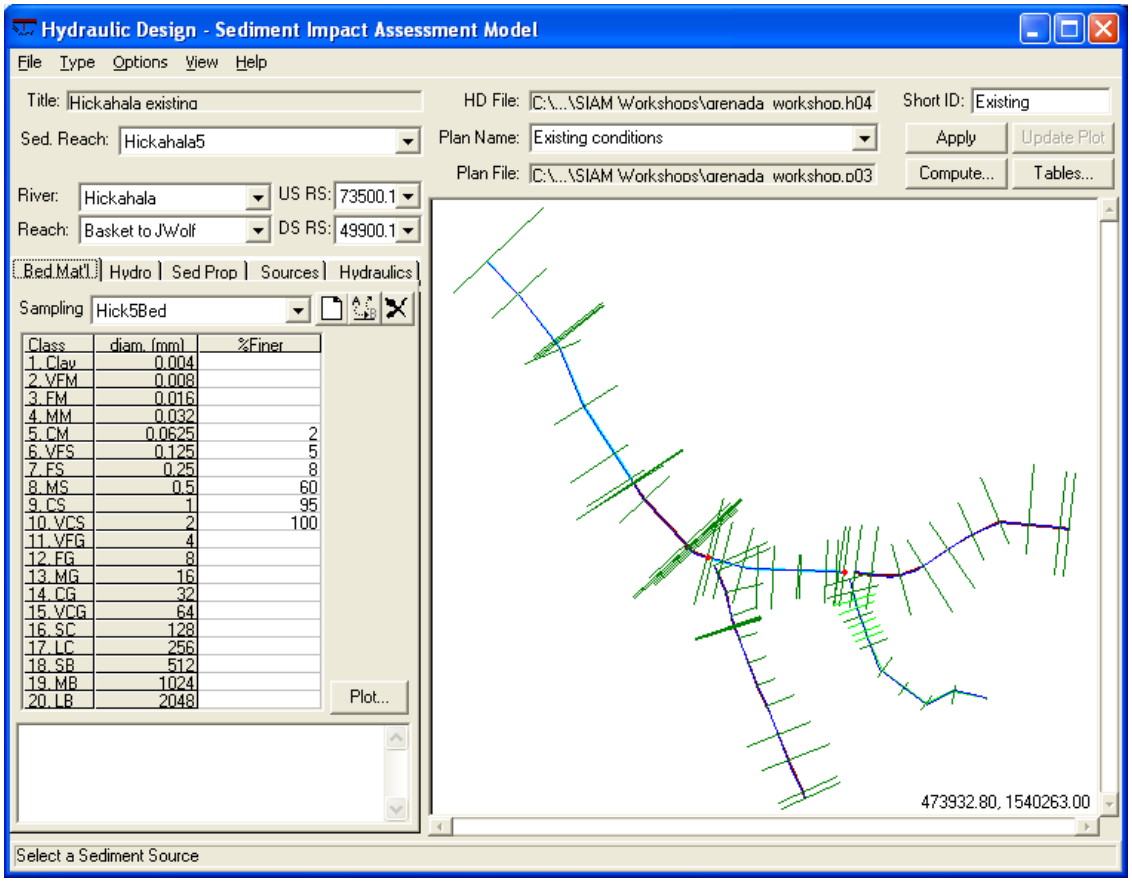
Why? A channel network is not simply a network of pipes conveying sediment.

Streams and rivers are formed of the sediment they transport.



Sediment Impact Analysis Method (SIAM)

code developed by David Mooney (now with BuRec)
incorporated into HEC-RAS for ease of use
Corps POCs: Stan Gibson (HEC), Charlie Little (ERDC)



HEC-RAS/SIAM
Interface

SIAM Highlights/Capabilities

- Reach-based sediment accounting
  - sediment transport parameters
  - grain size class.
- Long-term channel stability
  - Compares transport capacity with bed material supply
  - Net sediment balance for reach
- Distinguishes bed material load and wash load
  - User defined wash material threshold
  - Allows bed and wash material to interchange
- Easily manipulated to customize sediment loading.
- TIMELY ASSESSMENT OF ALTERNATIVES

SIAM Highlights/Capabilities

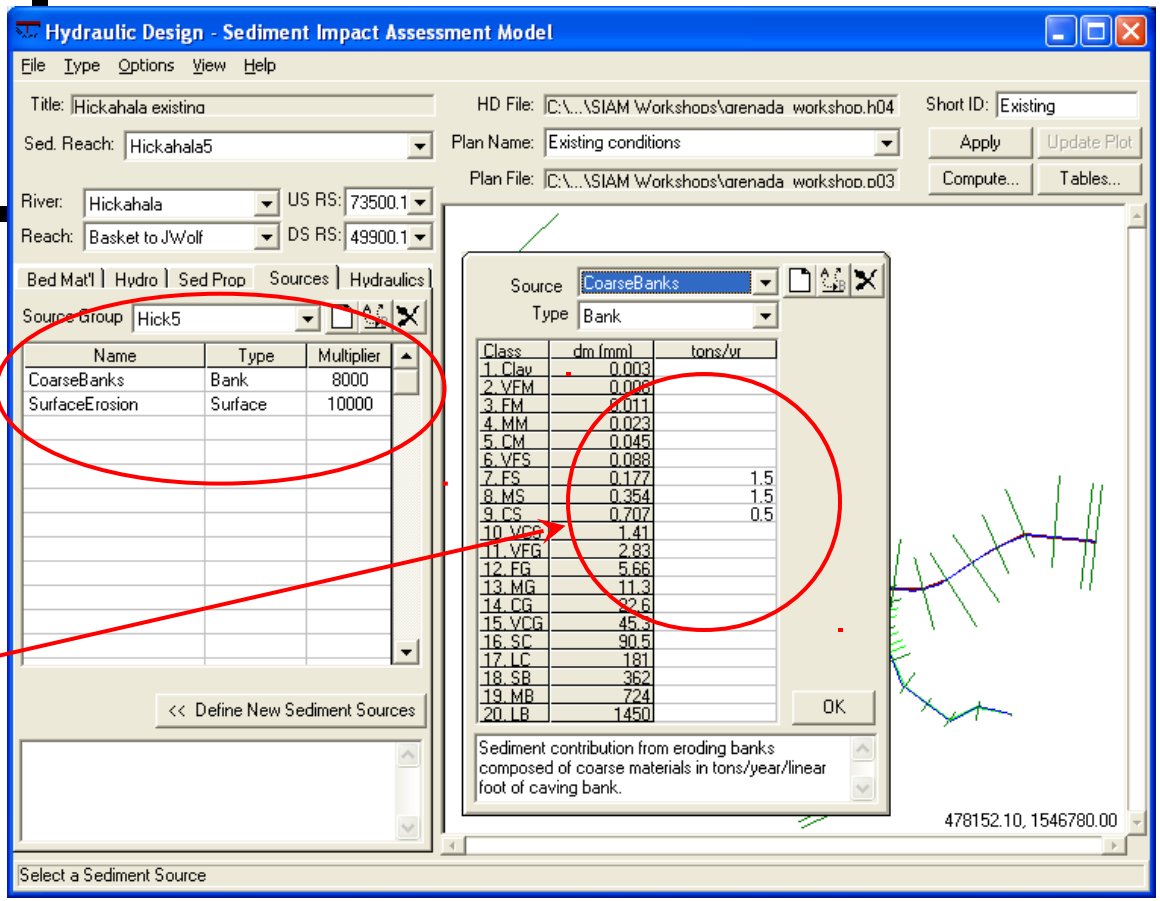
- Sensitivity analyses
- Particle tracking by sediment size
- sediment sources and sinks. all inputs to the sediment load – not just watershed yield.
- Bridges gap between watershed sediment yield / in-channel sediment transport models
- New combination of applications
  - Underlying theory is proven.
  - extends sediment processes evaluation
- Technical support for decision-making

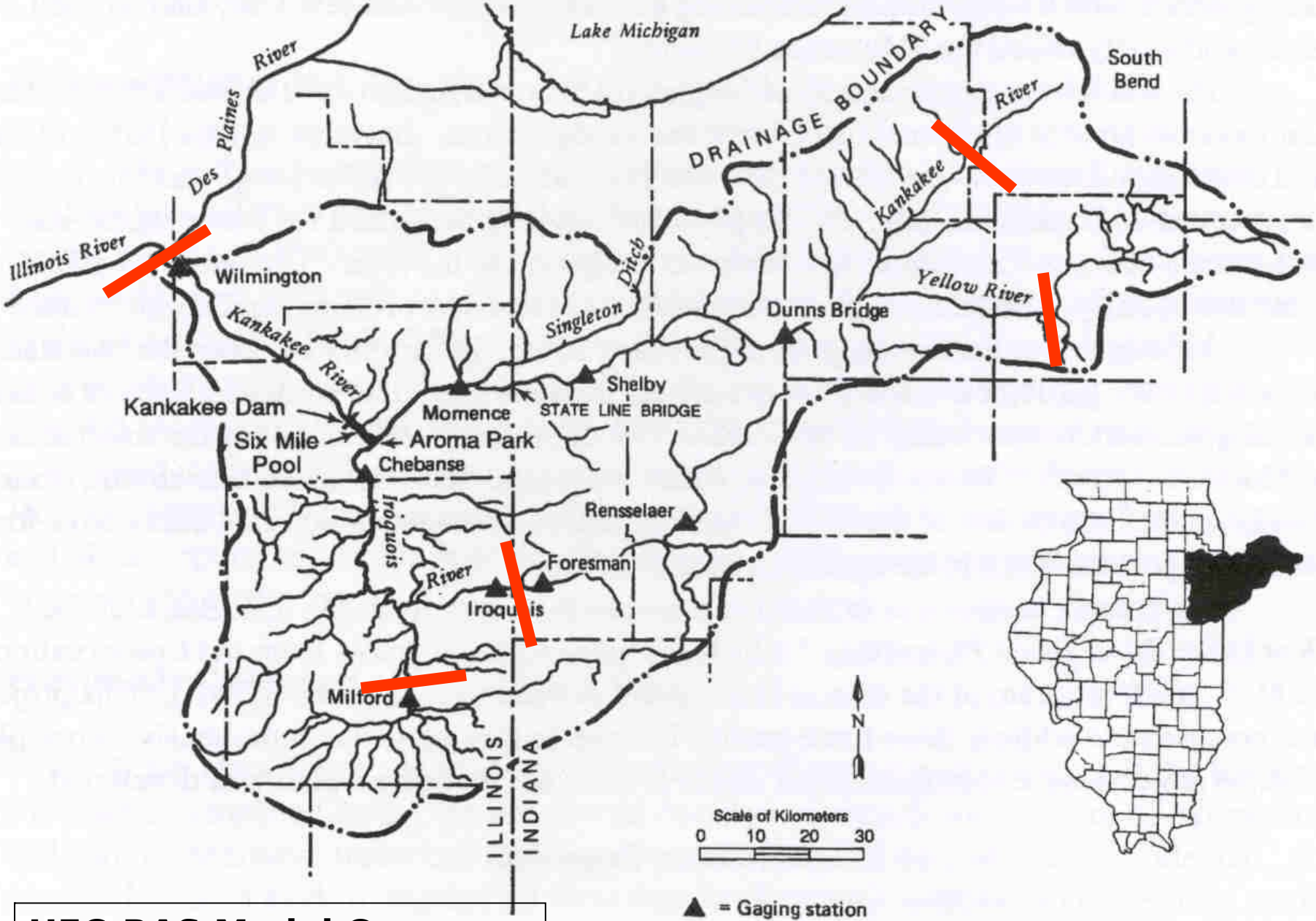
SIAM Input Data

- **Bed material gradation**
- **Hydrology/flow duration**
- **Sediment properties**
- Sediment sources/loadings
- **Hydraulics**

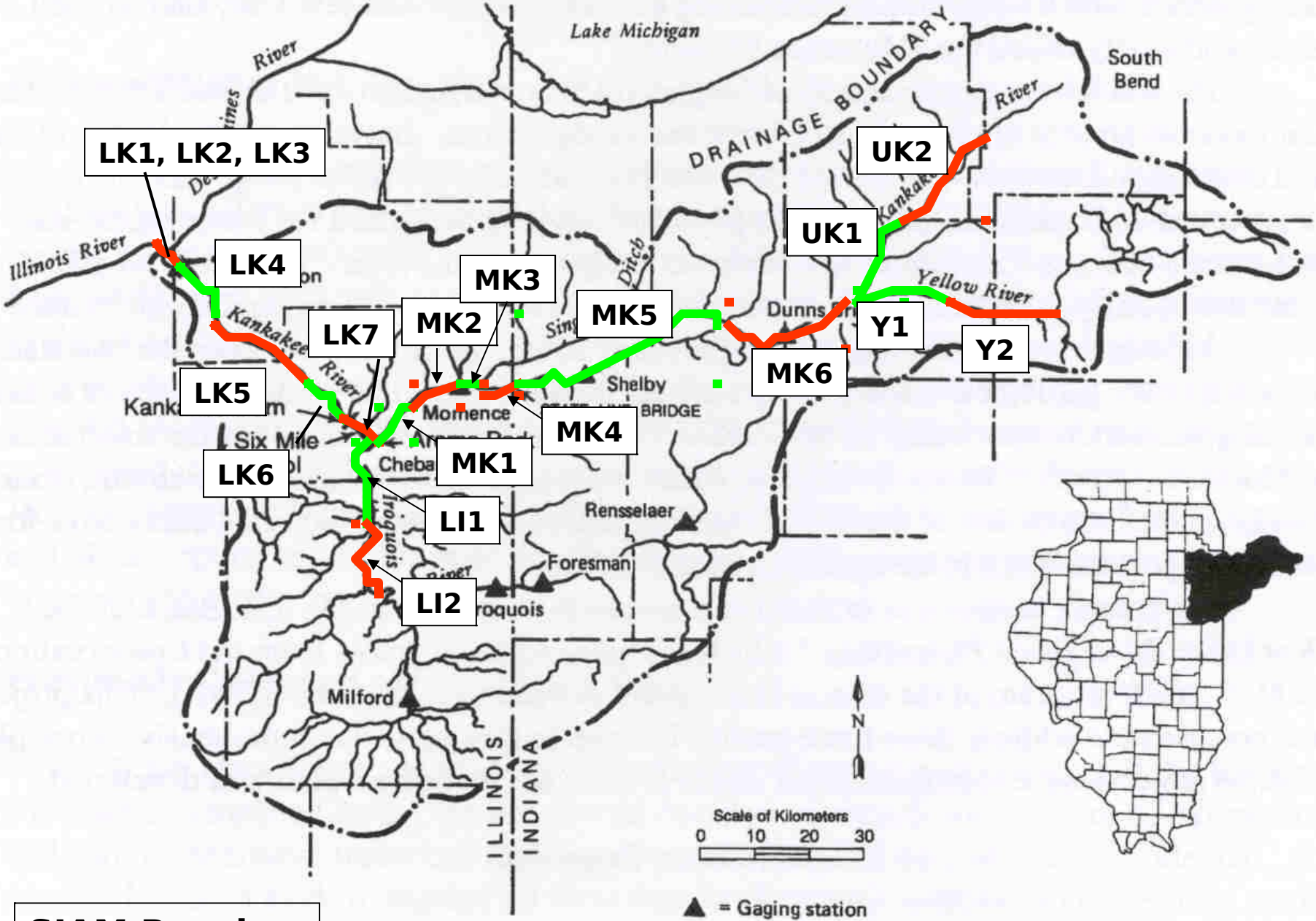
Sediment source loads for reach

Rate and distribution of sediment source





HEC-RAS Model Coverage



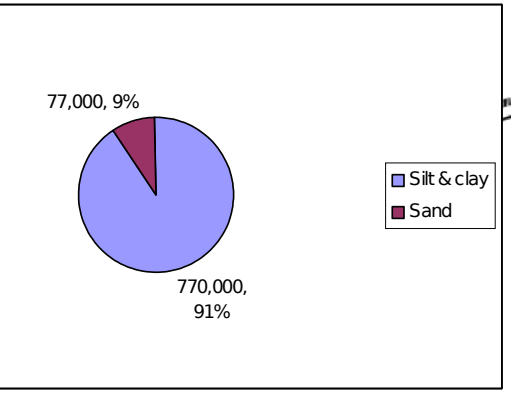
SIAM Reaches

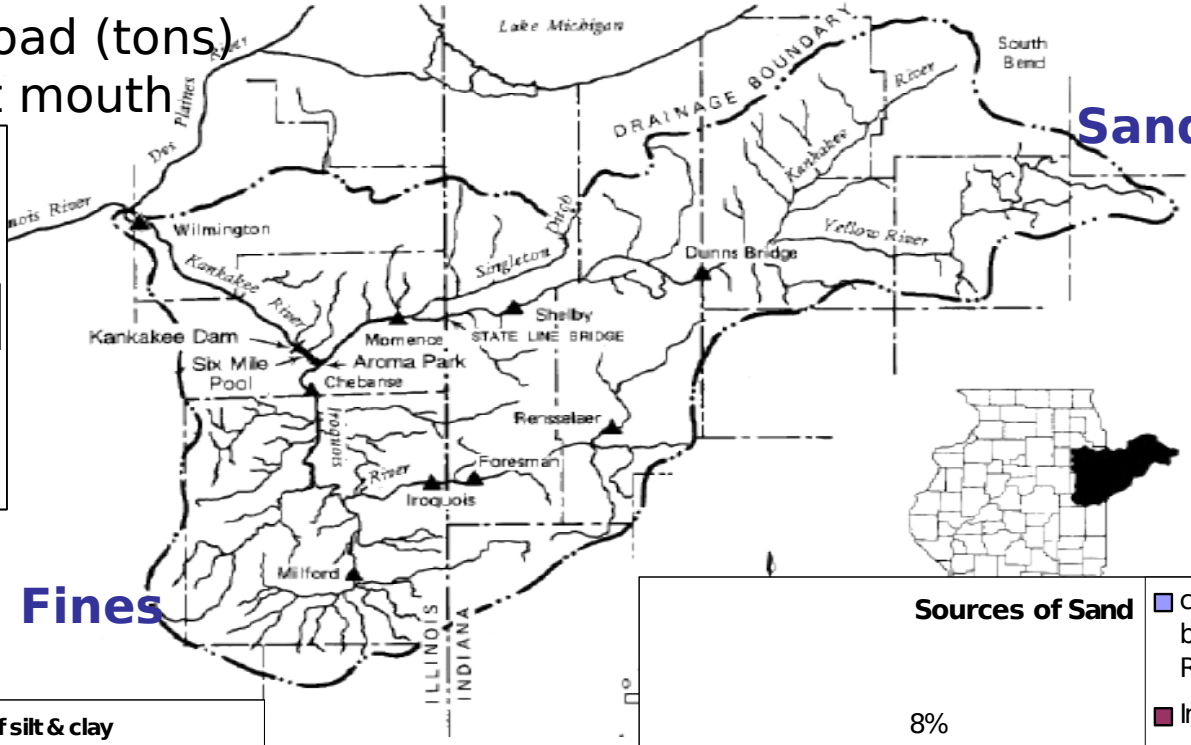
SIAM Results – First (not last) Trial for Existing Conditions

Reach	Wash Supply (tons/yr)	Obs. Sus. Sediment (tons/yr)
Lower Kankakee - LK1	852,000	
LK2	849,000	846,900 (Wilmington)
LK3	849,000	
LK4	906,000	
LK5	906,000	
LK6	709,000	753,600 (Kankakee)
LK7	658,000	
Middle Kankakee - MK1	248,000	
Momence - MK2	197,000	205,500 (Momence)
MK3	197,000	
MK4	175,000	
Shelby - MK5	137,000	130,000 (Shelby)
MK6	92,700	
UK1	11,000	
UK2	11,000	
Iroquois River - LI1	359,000	369,700 (at mouth)
LI2	51,300	
Yellow River - Y1	37,900	37,070 (at mouth)

Kankakee River Basin, Illinois and Indiana
Sources of Fine and Coarse Sediment
Numbers derived from multiple reports. Measured data rule

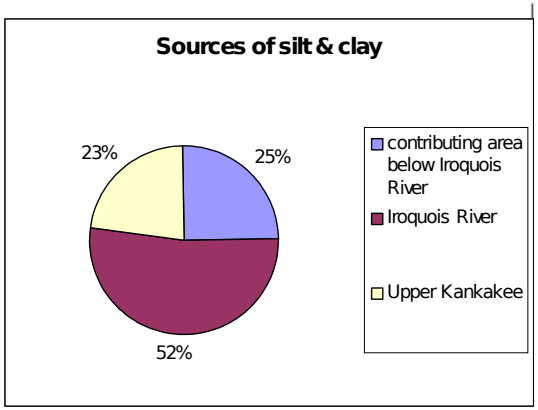
Average Annual Load (tons)
Kankakee River at mouth

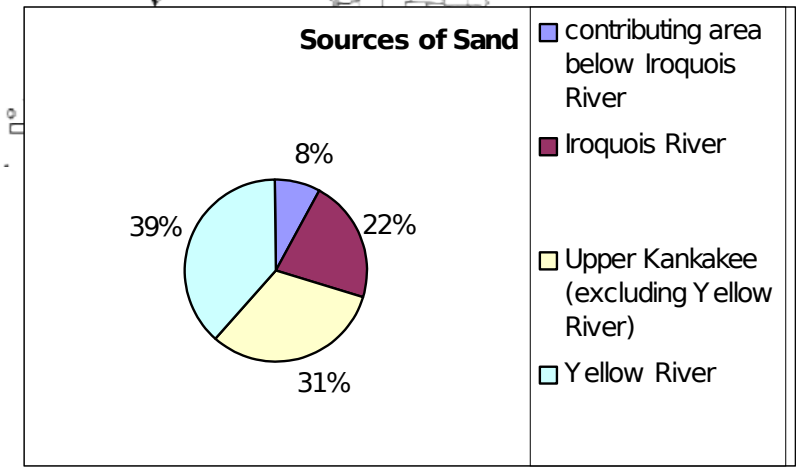




Sand belt

Fines





Kankakee River Basin
SIAM runs

- Existing conditions
- Alt1: Remove bank erosion source from Yellow River
- Alt2: Reduce watershed source loads from Yellow River by 50 percent
- Alt3: Reduce watershed source loads from Iroquois River by 50 percent
- Alt4: Reduce watershed source loads from Kankakee River above state line by 50 percent
- Alt5: Simulate re-meandering of Kankakee River reach from state line through Shelby (SIAM reach M5) by increasing HEC-RAS channel lengths by a factor of 3.

Kankakee – Preliminary SIAM Results

SIAM - **PRELIMINARY RESULTS** - Local Balance and Total Load in tons/year

Reach	Existing local bal	Existing total	Alt 1 local bal	Alt 1 total	Alt2 local bal	Alt2 total	Alt3 local bal	Alt3 total	Alt4 local bal	Alt4 total	Alt5 local bal	Alt5 total
LK1	0	947,000	0	943,000	0	931,000	0	738,000	0	895,000	0	947,000
LK2	-4,508	1,077,000	-4,508	1,073,000	-4,508	1,061,000	-4,508	868,000	-4,508	1,025,000	-4,508	1,077,000
LK3	0	917,000	0	914,000	0	901,000	0	708,000	0	866,000	0	917,000
LK4	-124,000	922,000	-124,000	918,000	-124,000	906,000	-124,000	712,000	-124,000	870,000	-124,000	922,000
LK5	0	715,000	0	711,000	0	699,000	0	506,000	0	663,000	0	715,000
LK6	0	683,000	0	679,000	0	667,000	0	473,000	0	631,000	0	683,000
LK7	69,300	643,600	69,300	639,600	69,300	627,600	69,300	434,600	69,300	591,600	69,300	643,600
MK1	-12,500	295,300	-12,500	292,300	-12,500	279,300	-12,500	295,300	-12,500	244,300	-12,500	295,300
MK2	0	217,000	0	213,000	0	201,000	0	217,000	0	165,000	0	217,000
MK3	-21,100	174,500	-21,100	170,500	-21,100	158,500	-21,100	174,500	-21,100	122,400	-21,100	174,500
MK4	2,081	146,400	2,081	142,400	2,081	130,400	2,081	146,400	2,081	94,600	-16,700	146,400
MK5	-6,859	128,800	-6,859	125,800	-6,859	113,100	-6,859	128,800	-8,998	77,200	9,204	109,986
MK6	33,000	91,600	33,000	88,000	33,000	75,600	33,000	91,600	30,900	52,900	35,700	88,912
UK1	2,974	22,033	2,974	22,033	2,974	22,033	2,974	22,033	124	12,423	2,978	22,029
UK2	2,413	5,987	2,413	5,987	2,413	5,987	2,413	5,987	1,153	3,047	2,413	5,987
LI1	-18,900	439,600	-18,900	439,600	-18,900	439,600	-18,900	229,600	-18,900	439,600	-18,900	439,600
LI2	-1,765	240,765	-1,765	240,765	-1,765	240,765	-1,765	121,765	-1,765	240,765	-1,765	240,765
Y1	19,800	72,100	-569	68,500	18,000	56,200	19,800	72,100	18,000	56,200	19,800	72,100
Y2	-30,900	55,900	-30,900	55,900	-31,600	44,200	-30,900	55,900	-31,600	44,200	-30,900	55,900

degradational or less sediment

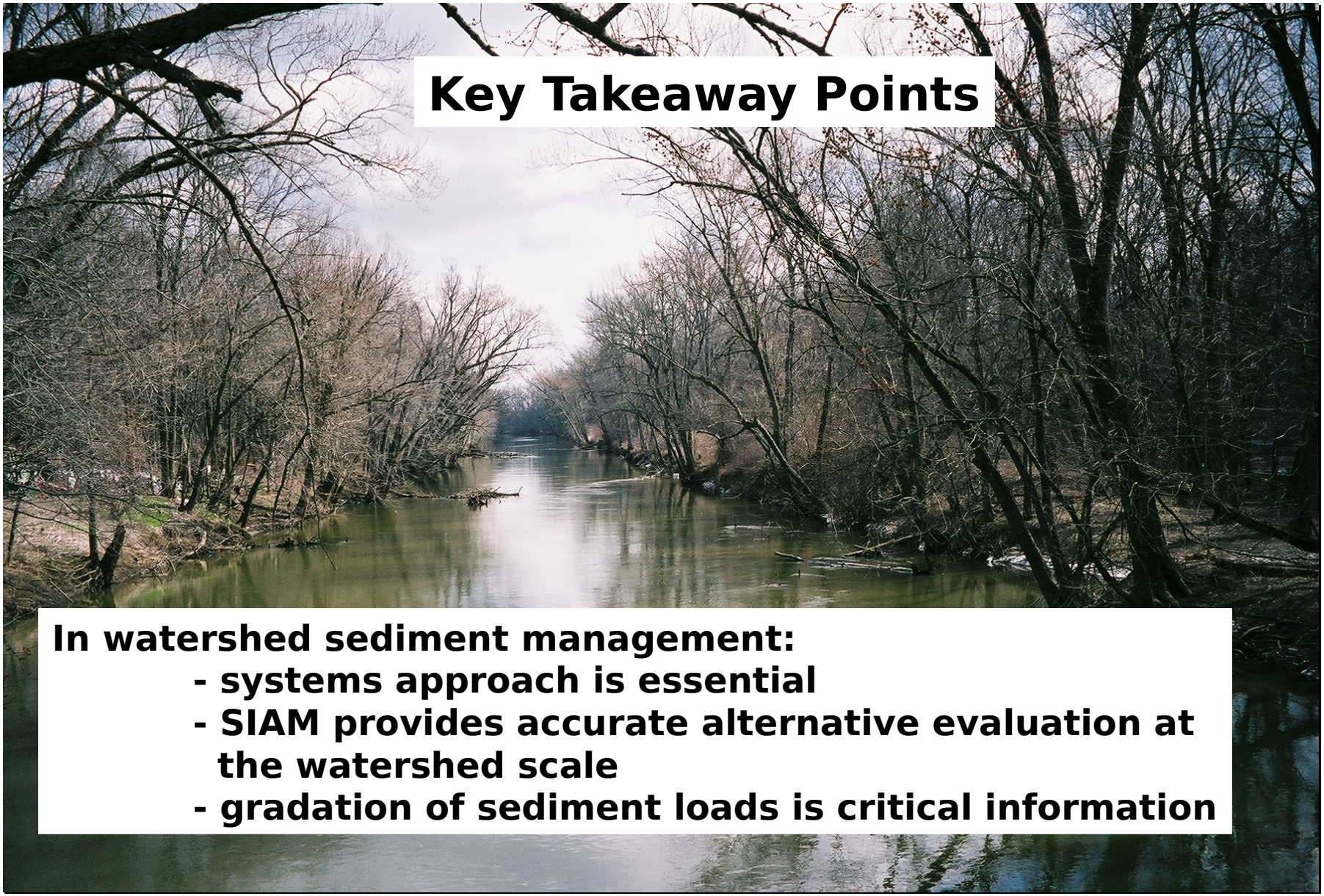
aggradational or more sediment

Total load computed for downstream end of reach
Total load is mostly (but not all) fines.

Alt 1 - Yellow River bank erosion reduced by 100% (sand)
Alt 2 - Yellow River watershed yield reduced by 50%
Alt 3: Iroquois River watershed source loads reduced by 50 percent
Alt 4: Kankakee River (above state line) watershed source loads reduced by 50%
Alt 5: Re-meandering of Kankakee River reach from state line through Shelby (SIAM reach M5)

Proposed Next Steps

- Obtain consensus on the input data and assumptions for the existing conditions SIAM model
- Discuss alternatives and rerun for mainstem
- Improve estimates of sediment sources (Yellow River in particular) for both existing conditions and alternatives
- Refine model to address Yellow River (existing and alternatives) in more detail

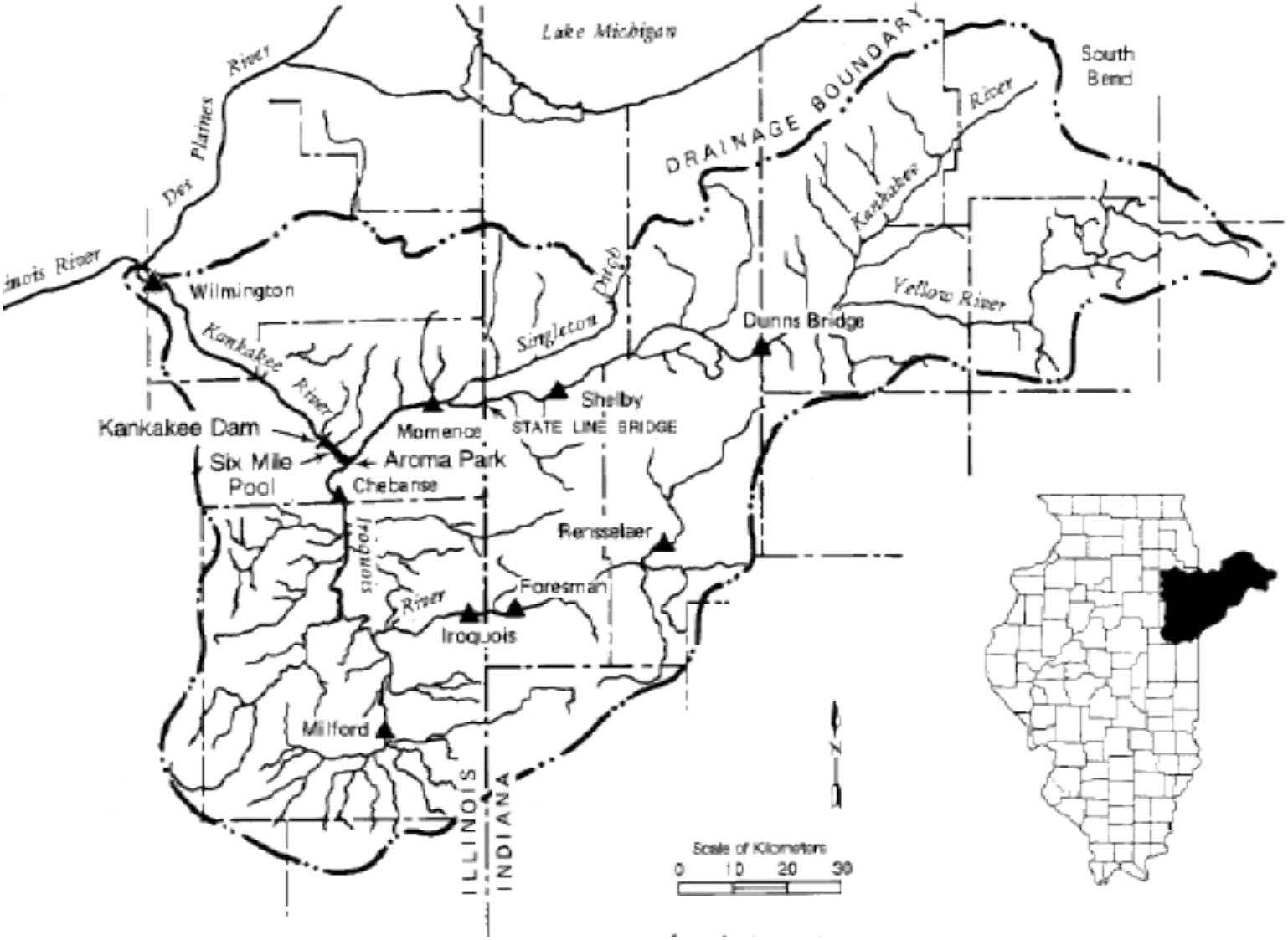


Key Takeaway Points

In watershed sediment management:

- **systems approach is essential**
- **SIAM provides accurate alternative evaluation at the watershed scale**
- **gradation of sediment loads is critical information**

Any Questions?



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